A Search for Substructure in High X-ray Luminosity Clusters of Galaxies

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Principal Investigator
Dr. Margaret J. Geller

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Smithsonian Institution
Astrophysical Observatory
Cambridge, Massachusetts 02138

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is a member of the
Harvard-Smithsonian Center for Astrophsysics

We proposed ROSAT observations of the five rich clusters of galaxies: A1736, DC0559-40, A1644, A754, and Ser 40/6. We were awarded observing time for only one of these, Ser 40/6. The ROSAT observation of this rich cluster reveals the substructure in the system in remarkable detail. The cluster consists of at least three subclumps.

We are in the process of making a detailed model of the system in collaboration with Prof. Evrard (University of Michigan) and his student Mary Crone. They construct detailed hydrodynamic models of x-ray emission from clusters. Their state-of-the-art code enables a sophisticated interpretation of the way the x-ray surface brightness profile and temperature structure reflect the recent merger of subclumps in the cluster.

Our original interest in proposing ROSAT observations was to obtain a better understanding of the nature and origin of substructure in clusters. We have now developed a new, general technique for detecting a signal for substructure in x-ray surface brightness distributions. For this program, we obviously need more than one cluster observation. We are therefor combining our ROSAT observation with other available data.

In our paper *An X-Ray Method for Detecting Substructure in Galaxy Clusters: Application to Perseus, A2256, Centaurus, Coma, and Sersic 40/6* by J. Mohr, D. Fabricant, and M. Geller (*Ap. J.*, 1993 **413**, 492), we use the moments of the x-ray surface brightness distribution to constrain the dynamical state of a galaxy cluster. We argue that a significant variation in the image centroid as a function of radius is evidence for a non-equilibrium feature in the ICM density distribution. For each cluster, we evaluate the significance of variations in the centroid of the Einstein IPC image by computing the same statistics on an ensemble of simulated cluster images. The core of each of the five clusters we examine in detail has significant substructure.

For a statistical ensemble of clusters, the frequency of substructure is a constraint on the universal mean mass density Ω. This connection, suggested by Richstone, Loeb, and Turner (1992), is supported by n-body simulations. Working with A. Evrard, we have demonstrated a morphology-cosmology connection. We apply the analysis technique developed for the Einstein data (and applicable to the ROSAT data) to the simulations. Low Ω models do not match the cluster data. This result is in puzzling contrast to the statistical measures of large-scale structure in the galaxy distribution which point to a low $\Omega \simeq 0.2$. We are now completing a paper which compares structure parametes for $\sim$60 observed cluster x-ray surface brightness profiles with simulations (Mohr*et al.* 1994). The distributions of centroid shift, ellipticity, and profile steepness all favor high Ω models just as in our preliminary assay.

We now plan to extend these investigations by combining optical spectroscopic and photometric data with the x-ray images for Ser 40/6 among others. We plan a set of papers along the lines of our study of A119 (Fabricant *et al.* 1993).

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